CLAIMS

Having thus described the invention, what is claimed is:

1. A pressure-differential liquid raising system, comprising:

(a) a system inlet at a first elevation for receiving liquid;

(b) a system outlet at a second elevation higher than the first elevation;

(c) at least one cell at a third intermediate elevation between the first and second elevations, said at least one cell having a cell liquid inlet and a cell liquid outlet;

(d) a first liquid-conveying conduit having a first conduit liquid inlet in common with the system inlet at the first elevation, and a first conduit liquid outlet in a respective first said cell at a third elevation, corresponding to a first liquid inlet of the respective first said cell, said third elevation being higher than the first elevation of the first conduit liquid inlet;

(e) a second liquid-conveying conduit having a second conduit liquid inlet in common with a second liquid outlet of the respective first said cell, and a second conduit liquid outlet at a higher fourth elevation than the second conduit liquid inlet; and

(f) pressure differential apparatus adapted to supply a first pressure differential between the system inlet and the respective first said cell, thereby to cause liquid at the system inlet to flow through the first liquid-conveying conduit to the respective first said cell, said pressure differential apparatus being further adapted to apply a second different pressure differential between the first said cell and one of a downstream said cell and the system outlet, and to simultaneously apply the second pressure differential between the first said cell and the system inlet thereby to cause liquid from the respective first said cell to flow in the downstream direction through the second liquid-

conveying conduit along a liquid flow path toward the system outlet as well as to cause a nominal amount of the liquid to flow from the first said cell upstream toward said system inlet.

2. A pressure-differential liquid raising system as in Claim 1 wherein liquid is raised from a source reservoir at said system inlet and flows in a downstream direction through the respective first said cell in response to cyclically applying the first and second pressure differentials.

3. A pressure-differential liquid raising system as in Claim 1 wherein the first liquid-conveying conduit comprises first and second liquid-conveying columns in liquid communication with each other and which collectively define a liquid flow path, and wherein a portion of the liquid flow path is disposed at a lower elevation than the system inlet.

4. A pressure-differential liquid raising system as in Claim 1, further comprising multiple substantially closed vertically-adjacent upstream and downstream cells at respective intermediate elevations between the system inlet and the system outlet, and corresponding multiple liquid-conveying conduits between vertically-adjacent upstream and downstream said cells, each of the corresponding multiple said liquid-conveying conduits having a liquid inlet in the respective vertically-adjacent upstream cell and a liquid outlet in the respective vertically-adjacent downstream cell.

5. A pressure-differential liquid raising system as in Claim 1, further comprising a source reservoir, the source reservoir being substantially closed to casual ambient air pressure.

6. A pressure-differential liquid raising system as in Claim 3 wherein the liquid flow path extends downwardly from the system inlet along the first column, and upwardly along the second column to the first liquid outlet.

7. A pressure-differential liquid raising system as in Claim 1, further comprising a destination reservoir for receiving liquid from the system outlet, wherein the destination reservoir is substantially closed to casual ambient air pressure.

8. A pressure-differential liquid raising system as in Claim 1 wherein the first and second liquid-conveying conduits are free from structure which would substantially impede flow of liquid therein.

9. A pressure-differential liquid raising system as in Claim 1 wherein the first and second liquid-conveying conduits are free from structure which would stop flow of liquid therein.

10. A pressure-differential liquid raising system as in Claim 2 wherein the liquid in the second liquid-conveying column of the first liquid-conveying conduit is at a lower elevation than the liquid in the first liquid-conveying column of the first liquid-conveying conduit in response to applying the second pressure differential to the respective said cell, but wherein the liquid in the first liquid-conveying conduit prevents air in the respective said cell from passing upstream in the liquid flow path beyond the first liquid-conveying conduit.

11. A pressure-differential liquid raising system as in Claim 1, said liquid raising system comprising an in-ground assembly for installation below ground level "G", said in-ground assembly being free from moving parts and parts which require routine repair or maintenance.

12. A pressure-differential liquid raising system as in Claim 1, installed in the ground and reaching into an underground source reservoir of liquid, wherein the underground source reservoir is defined by underground geological structure.

13. A pressure-differential liquid raising system, for moving liquid, from a first elevation, to a second elevation higher than the first elevation, said system comprising:

(a) a system inlet at the first elevation, for receiving liquid, into the system;

(b) a system outlet at the second elevation;

(c) at least one cell between the system inlet and the system outlet;

(d) a first liquid-conveying conduit having a first conduit liquid inlet in common with the system inlet, and a first conduit liquid outlet in a respective first said cell at a first elevation, and first and second liquid-conveying columns, portions of each of said first and second liquid-conveying columns being at lower elevations than the system inlet;

(e) a second liquid-conveying conduit having a second conduit liquid inlet in common with a first liquid outlet of the respective first said cell, and a second conduit liquid outlet above a floor of the respective first said cell; and

(f) pressure differential apparatus adapted to supply pressure differentials between the system inlet and the respective first said cell, thereby to cause liquid at the system inlet to flow in a downstream direction from the system inlet through the first liquid-conveying conduit to the respective first said cell, and to cause the liquid to flow in the downstream direction from the respective said cell.

14. A pressure-differential liquid raising system as in Claim 13, said pressure-differential liquid raising system being adapted to cyclically apply a second pressure differential between the respective said one of a downstream said cell and the system outlet.

15. A pressure-differential liquid raising system as in Claim 13 wherein at least one of the first and second liquid-conveying conduits is free from structure which would substantially restrict flow of liquid in the respective said liquid-conveying conduit.

16. A pressure-differential liquid raising system as in Claim 13 wherein at least one of the first and second liquid-conveying conduits is free from structure which would stop flow of liquid in the respective said liquid-conveying conduit.

17. A pressure-differential liquid raising system as in Claim 13, further comprising a destination reservoir, and wherein the destination reservoir is a substantially closed container.

18. A pressure-differential liquid raising system as in Claim 13 wherein the first liquid-conveying conduit comprises first and second columns in liquid communication with each other and which collectively define a liquid-conveyance path, and wherein the liquid is at first and second different elevations in the first and second columns in response to applying the second pressure differential to the respective said cell.

19. A pressure-differential liquid raising system as in Claim 13, further comprising multiple vertically-adjacent upstream and downstream cells in liquid communication with each other at respective elevations, each being between the first and second elevations, and an intermediate liquid-conveying conduit between each respective pair of vertically-adjacent cells, each liquid-conveying conduit having a cell inlet in the respective said upstream cell and a cell outlet in the respective said downstream cell.

20. A pressure-differential liquid raising system as in Claim 13, installed in the ground and reaching into an underground source reservoir of liquid, wherein the underground source reservoir is defined by underground geological structure.

21. A pressure-differential liquid raising system, for moving liquid, from a first elevation, to a second elevation higher than the first elevation, said system comprising:

(a) a system inlet at the first elevation, for receiving liquid into the system;

(b) a system outlet at the second elevation;

(c) at least one cell between the system inlet and the system outlet;

(d) a liquid-conveying conduit having a first conduit liquid inlet in common with a first liquid outlet of a first said cell inlet, and a first conduit liquid outlet in a respective second said cell at a first elevation, and first and second liquid-conveying columns, portions of each of said first and second liquid-conveying columns being at lower elevations than the first liquid conduit inlet;

(e) a second liquid-conveying conduit having a second conduit liquid inlet in common with a second liquid outlet of the respective second said cell, and a second conduit liquid outlet above a floor of the respective second said cell; and

(f) pressure differential apparatus adapted to supply pressure differentials between the first said cell and the respective second said cell.

22. A pressure-differential liquid raising system as in Claim 21, said pressure-differential liquid raising system being adapted to cyclically apply a second pressure differential between the respective said one of a downstream said cell and the system outlet.

23. A pressure-differential liquid raising system as in Claim 21, said pressure differential liquid raising system being adapted to cyclically apply a first pressure differential between the respective said one of a downstream said cell and the system

outlet, thereby to cause the liquid to flow in the downstream direction from the respective said cell.

24. A pressure-differential liquid raising system as in Claim 21 wherein at least one of the first and second liquid-conveying conduits is free from structure which would substantially restrict flow of liquid in the respective said liquid-conveying conduit.

25. A pressure-differential liquid raising system as in Claim 21 wherein at least one of the first and second liquid-conveying conduits is free from structure which would stop flow of liquid in the respective said liquid-conveying conduit.

26. A pressure-differential liquid raising system as in Claim 21, further comprising a destination reservoir, and wherein the destination reservoir is a substantially closed container.

27. A pressure-differential liquid raising system as in Claim 21 wherein the first liquid-conveying conduit comprises first and second columns in liquid communication with each other and which collectively define a liquid-conveyance path, and wherein the liquid is at first and second different elevations in the first and second columns in response to applying the second pressure differential to the respective said cell.

28. A pressure-differential liquid raising system as in Claim 21, further comprising multiple vertically-adjacent upstream and downstream cells in liquid communication with each other at respective elevations, each being between the first and second elevations, and an intermediate liquid-conveying conduit between each respective pair of vertically-adjacent cells, each liquid-conveying conduit having a cell inlet in the respective said upstream cell and a cell outlet in the respective said downstream cell.

29. A pressure-differential liquid raising system as in Claim 21, installed in the ground and reaching into an underground source reservoir of liquid, wherein the underground source reservoir is defined by underground geological structure.

30. A pressure differential liquid raising system, comprising:

(a) a system inlet at a first elevation for receiving liquid;

(b) a system outlet at a second elevation higher than the first elevation;

(c) a plurality of cells at intermediate elevations between the first and second elevations, each said cell having a top wall, a floor, a cell liquid inlet, a cell liquid outlet, and a gas port;

(d) liquid-conveying conduits connecting next vertically adjacent ones of said cells to each other at conduit liquid inlets at upstream ones of said adjacent cells and conduit outlets at the relatively downstream ones of said cells, each said liquid-conveying conduit having a downwardly extending column at an upstream end of said conduit, extending downwardly to an elevation below the floor of the respective said cell whereby a portion of the respective said liquid-conveying conduit is at an elevation lower than the lowest component of the respective said cell; and

(e) pressure differential apparatus adapted to supply pressure differentials between respective ones of said cells.

31. A pressure differential liquid raising system as in Claim 30 wherein a height of the portion of a respective said conduit which is below the floor of the respective said cell is greater than a height from the cell liquid inlet to the top wall of the next adjacent downstream cell.

32. A pressure differential liquid raising system as in Claim 30 wherein a height of the portion of a respective said conduit which is below the floor of the respective said cell is greater than the height between the floor of the respective said cell and the top wall of the next vertically-adjacent said cell.

33. A pressure differential liquid raising system as in Claim 30 wherein said system is free from parts requiring routine repair or maintenance below at least one of the pressure differential apparatus and a destination reservoir.

34. A pressure-differential liquid raising system as in Claim 30, installed in the ground and reaching into an underground source reservoir of liquid, wherein the underground source reservoir is defined by underground geological structure.

35. A pressure differential liquid raising system, for moving liquid, comprising:

(a) an in-ground assembly comprising
  (i) a system inlet,
  (ii) at least one in-ground cell, having a top wall, and a floor, and
  (iii) liquid-conveying conduits adapted to convey the liquid to and through said at least one in-ground cell; and

(b) an above ground assembly connected to the in-ground assembly, said above-ground assembly comprising
  (iv) a system outlet at a destination reservoir adapted to receive liquid raised through said at least one cell,
  (v) a pressure differential source, and
  (vi) pressure control apparatus for cycling the pressure differential between the respective said cells, between a most downstream one of said cells and said destination reservoir, and between a most upstream one of said cells and a source reservoir,

said in-ground assembly being free from parts which routinely require repair or maintenance.

36. A pressure differential liquid raising system as in Claim 35 wherein a respective said liquid-conveying conduit conveying liquid from a respective said cell comprises a liquid flow path disposed at lower elevations than the floor of the respective said cell.

37. A pressure differential liquid raising system as in Claim 35, said in-ground assembly further comprising multiple vertically-adjacent upstream and downstream ones of said cells, and corresponding multiple said liquid-conveying conduits between vertically adjacent upstream and downstream ones of said cells each of the corresponding multiple said liquid-conveying conduits having a liquid inlet in the respective vertically-adjacent upstream cell and a liquid outlet in the respective vertically-adjacent downstream cell.

38. A pressure differential liquid raising system as in Claim 35 wherein the first and second liquid-conveying conduits in the in-ground assembly are free from structure which would substantially impede flow of liquid therein.

39. A pressure differential liquid raising system as in Claim 35 wherein the first and second liquid-conveying conduits in the in-ground assembly are free from structure which would stop flow of liquid therein.

40. A pressure-differential liquid raising system as in Claim 35, installed in the ground and reaching into an underground source reservoir of liquid, wherein the underground source reservoir is defined by underground geological structure.

41. A method of raising liquid from a system inlet at a first elevation to a system outlet at a second elevation higher than the first elevation, the method comprising:

(a) providing at least one cell at an intermediate elevation between the first and second elevations;

(b) applying a first pressure differential between one of
  (i) the system inlet and a first one of the respective cells,
  (ii) first and second ones of the cells, and
  (iii) one of the cells and the system outlet, and thereby causing the liquid to flow downwardly from the respective one of the system inlet and a respective one of the cells in a downstream direction to a third elevation lower than the first elevation, and subsequently causing the liquid to flow in the downstream direction and upwardly and to the respective first one of the cells, the second one of the cells, and the system outlet; and

(c) applying a second pressure differential between the respective cell and one of a second said cell and said system outlet and thereby causing the liquid to flow from the respective cell in the downstream direction and toward the system outlet at the second elevation.

42. A method as in Claim 41 wherein causing the liquid to flow into the respective cell at a fourth elevation, and wherein causing the liquid to flow from the respective cell comprises causing the liquid to flow from the respective said cell at a fifth elevation lower than the fourth elevation.

43. A method as in Claim 41, further comprising conveying the liquid through a sufficient number of cells, at sufficient pressure differential between the cells, to lift the liquid at least 40 feet in elevation.

44. A method as in Claim 41, further comprising conveying the liquid through a sufficient number of cells, at sufficient pressure differential between the cells, to lift the liquid at least 70 feet in elevation.

45. A method as in Claim 41, further comprising conveying the liquid through a sufficient number of cells, at sufficient pressure differential between the cells, to lift the liquid at least 100 feet in elevation.

46. A method as in Claim 41, further comprising drawing liquid into the system at the system inlet from an underground source reservoir defined by underground geological structure.

47. A method of raising liquid from a system inlet at a first elevation to a system outlet at a second elevation higher than the first elevation, the method comprising:

(a) providing an in-ground assembly comprising
  (i) a system inlet,
  (ii) at least one in-ground cell, having a top wall and a floor, and
  (iii) liquid-conveying conduits adapted to convey the liquid to and through the at least one in-ground cell;

(b) providing an above-ground assembly connected to the in-ground assembly, the above-ground assembly comprising
  (iv) a system outlet at a destination reservoir adapted to receive liquid raised through the cells,
  (v) a pressure differential source, and
  (vi) pressure control apparatus; and

(c) applying cyclic sequential pressure differentials to the in-ground assembly thus to cause liquid to flow from the system inlet to the system outlet without use, in the in-ground assembly, of parts which require routine repair or maintenance.

48. A method as in Claim 47, including causing liquid to flow, from a respective cell downwardly below the floor of the cell and thence upwardly to a next vertically-adjacent cell.

49. A method as in Claim 48 wherein the height of the downward flow is sufficiently great to prevent back flow of air into the respective cell, from the next vertically-adjacent downstream cell when the pressure differential is reversed, and wherein the pressure differential is no greater than standard atmospheric pressure.

50. A method as in Claim 47, further comprising conveying the liquid through a sufficient number of cells, at sufficient pressure differential between the cells, to lift the liquid at least 40 feet in elevation.

51. A method as in Claim 47, further comprising conveying the liquid through a sufficient number of cells, at sufficient pressure differential between the cells, to lift the liquid at least 70 feet in elevation.

52. A method as in Claim 47, further comprising conveying the liquid through a sufficient number of cells, at sufficient pressure differential between the cells, to lift the liquid at least 100 feet in elevation.

53. A method as in Claim 47 wherein the in-ground assembly is free from moving parts.

54. A method as in Claim 47, further comprising drawing liquid into the system at the system inlet from an underground source reservoir defined by underground geological structure.